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Return on investment from educational research grant funding: deliverables and measurement

Ahmad Taufek Abdul Rahman[1], Mohd Hafiz Hanafiah[2], Umi Marshida Abd Hamid[3], Nor Azura Md Ghani[4], Nur Adilah Md Zain[2]
[1]Department of Physics & Materials Studies, Faculty of Applied Science, Universiti Teknologi MARA, Shah Alam, Malaysia
[2]Department of Tourism Management, Faculty of Hotel & Tourism Management, Universiti Teknologi MARA, Puncak Alam, Malaysia
[3]Department of Biology, Faculty of Applied Science, Universiti Teknologi MARA, Shah Alam, Malaysia
[4]Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia

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ABSTRACT

This paper investigates the return on investment (ROI) paradigm from fundamental educational research grant funding perspectives. The researchers conducted a wide-ranging literature search regarding the educational research grant funding ROI from public policy and economics viewpoints. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) were utilized to identify and analyze research articles and original reports related to ROI from educational research grant funding. The research data were screened through a literature review based on the inclusion criteria, namely study focusing on return on investment of educational research funding and study published between 2001 and 2021 (as of December 2021). This study found evidence that ROI calculation from fundamental educational research grants is not straightforward and varies. Besides, most available research focuses on research impact rather than economic and intrinsic research value. Based on the compiled literature on research-related performance attributes, this study identified three distinct deliverables of educational research funding: tangible output, intangible output, and research outcome. The present research proposes more robust and reliable methods for measuring the ROI of fundamental educational research impact, potentially generating a much-inform decision-making and resource allocation in educational research grant funding.

Corresponding Author:

Ahmad Taufek Abdul Rahman
Department of Physics & Materials Studies, Faculty of Applied Science, Universiti Teknologi MARA
40450 Shah Alam, Selangor Darul Ehsan, Malaysia
Email: ahmadtaufek@uitm.edu.my

1. INTRODUCTION

What is the value of fundamental research funding? Is it worth the investment of public funds? This is a question many government agencies and universities worldwide have been asking before committing to fundamental research investments. Notably, their aim to comprehend the research value and result is understandably justified from strategic management and economic perspectives. Besides, the need for such understanding extends to public investment policymaking. Hence, understanding return on investment is crucial to research communities, funders and the public. Since monetary inputs play a pivotal role in research activities, considering research value and efficacy will give universities a clearer understanding of the research performance. Besides, determining the impact of research on broader society may aid them in making future investment decisions. This understanding empowers them to make informed decisions

regarding resource allocation, research prioritization, and strategic partnerships, thereby optimizing their research endeavors.

An educational research grant is a financial award supporting academic personnel research projects. These grants are typically awarded by government agencies, private foundations, or non-governmental organizations interested in advancing knowledge and understanding in selected research areas [1]. These grants usually support research that focuses on individuals, organizations, and society as a whole. Educational research grants can be used to fund a variety of expenses associated with basic research activities. These may include payment of salaries for research staff, equipment and supplies, travel expenses, and other costs directly related to the research project [2]. The outcome of the research funding varies based on their innovative research objectives and significance. Usually, these grants help identify best practices, inform policy decisions, and ultimately improve educational outcomes for students and society [3], [4].

Expanding the assessment of research funding performance by examining research spending as an investment that should generate a quantifiable economic return is necessary. Since the 1990s, government-funded scientific research has been believed to bring bountiful economic advantage and thrive government educational policies [2]–[5]. Evidently, past studies reported a positive relationship between research funding and the series of publications published, patents granted, and expertise at research universities [6], [7]. However, with the current federal budget constraints, policymakers have been required to reassess spending and determine how to compare the significance of widely disparate government programs [8]. Since then, most governments have increased their expectations of universities to demonstrate the incredible benefits of academic research rather than making them implicit [9], [10]. Notably, it is worth noting that previous literature reviews have revealed a scarcity of systematic reporting on return on investment (ROI) in the context of educational research grant funding activities.

Previously, the ROI was neither the central purpose nor the primary reason for research grant expenditure [6], [8]. However, as accountability for public spending in education is much more critical than ever, it is imperative to measure the ROI to promote sustainable financing of educational research work in the future. Moreover, current practitioners are more concerned with economic and other quantifiable indicators of the success and value of research [11], [12]. Notably, there are numerous reasons why economic ROI calculations should not be used to evaluate government research expenditures. First, most ROI studies on research grants focus exclusively on the annual gain on previous investments [10]. Second, educational research expenditures are known as "public goods" whose market value is, by concept, difficult to quantify [11]. Thirdly, considering the success of the retrospective study, there is almost no established formula to measure educational research impact, and those that exist use a variety of non-identical attributes [12]. Notably, most of them argue that it is impossible to calculate or forecast the future ROI of research funding without such implications. Henceforth, essential questions persist: can something subjective and qualitative ever be appropriately measured?

Most academic research performance literature emphasizes quantity rather than quality, creating widespread arguments among researchers. Besides, applied research, which aims to solve practical problems, produces a more substantial economic impact than fundamental research. Thus, alternative "qualitative indicators" have been proposed to assess the fundamental research impact [8]–[11]. Besides, researchers also argue that it is challenging to quantify research funding impact and outcome [10], [13]. Logically, identifying the key tangible and intangible research funding outputs is critical in a holistic approach to fundamental research funding performance measurement. Still, there is a need to establish sound and commonly accepted definitions of what constitutes performance.

As a result, numerous researchers propose alternative methodologies for measuring quality and broader impact and volume [10], [11]. Despite the undeniable importance of assessing the value of fundamental research funding, it is worth noting that there exists a noticeable gap in the systematic reporting of ROI in educational research grant funding activities, as revealed by previous literature reviews. This gap underscores the ongoing need for rigorous evaluation methodologies and transparent reporting practices to ensure that the investment in fundamental research continues to yield valuable insights and innovations for the benefit of society at large. As such, this paper aims to elaborate on the possible research output and outcome to measure educational research grant impact.

This paper systematically reviews previous researchers' viewpoints regarding the ROI of research grant funding, specifically on the deliverables and assessment methods based on public policy and economics literature. In addition, this paper compares the findings among the selected previous studies to uncover the critical area that leads to this research's aims. This paper first introduces the research grant funding deliverables, highlighting its practices and exploring the research output and outcome. Next, this paper explores and interprets past research propositions on ROI measurement. The study findings offer an interpretation of more robust and reliable methods for measuring future fundamental educational research impact. The identified deliverables and assessment methods would enable research funding evaluation to evolve by recognizing the multitude of tangible and intangible output and research outcomes.

2. LITERATURE REVIEW

The earliest study on the ROI from research funding is by Grazier *et al.* [14], who did an impact study in the context of translational research. They propose a model for applying the ROI formula using data currently collected from the clinical and translational science awards (CTSA) program required financial and operating data. They argue that creating and sustaining the next generation of clinical and translational research requires a culture of innovation and excellence through the fair allocation of resources. On the other hand, a study by Deloitte Access Economics [15] on the national health and medical research council (NHMRC) research funding policy examines the ROI of research and development (R&D) investment by the NHMRC from 2000 to 2010. Their economic evaluation measures the net benefits and ROI through a Monte Carlo simulation. The study reported the ROI is most sensitive to the proportion of health gains attributed to global R&D and propose alternative methodologies for measuring output quality and impact.

On the other hand, Crawford and Jin [16] investigated the ROI in science and innovation for Institute for Fiscal Studies. They provide a comprehensive overview of the evidence relating to the rate of return to investment in science and innovation and learn how these returns vary across different kinds of investment (such as those in large capital facilities compared with investment in salaries and other 'current' knowledge spending). They suggest future studies to analyze the wider social returns to non-R&D intangible investment. Besides, they argue the need for further work to understand the wider 'public good' benefits of publicly-funded knowledge investments. In addition, Gök *et al.* [17] investigated the impact of research funding on scientific outputs by focusing on six smaller European countries. Their results propose insights for the design of research programs and the structure of research funding to be followed by researchers and sponsoring organizations.

Meanwhile, Van Elk *et al.* [18] did a macroeconomic analysis of the returns to public R&D investments. They analyze the economic returns to public R&D investments in 22 organization for economic co-operation and development (OECD) countries by controlling for private and foreign R&D investments and the primary production factors via the Cobb-Douglas models, translog models and augmented models' utilization. Their findings suggest that public R&D investments do not automatically foster gross domestic product (GDP) and total factor productivity (TFP) growth. Meanwhile, the economic return to scientific research seems to depend on the specific national context. Their study also found that the estimated returns to public R&D investments are not unambiguously positive and that the relationship between public R&D and economic performance is highly country-specific. Only models that allow for heterogeneity across countries provide positive and statistically significant estimates of the rates of return. Notably, their study asserts that microeconomic evaluations can provide insights into the effectiveness of specific institutions or science policy measures and learn how the value of science can be improved.

Koya and Chowdury [19] studied the metric-based vs. peer-reviewed evaluation of research output, focusing on United Kingdom's national research assessment exercise. They assume that there is a general inquisition regarding the monetary value of research output, as a substantial amount of funding in modern academia is essentially awarded to good research presented in the form of journal articles, conference papers, performances, compositions, exhibitions, books and book chapters, which eventually leads to another question if the value varies across different disciplines. Their findings indicate the monetary value of research output from the perspectives of government funding for research and what makes a good output and outcome out of the funding policy. Meanwhile, Lindsey [20] explore the link between an individual grant and subsequent research output and the effects of other sources of funding on the research output related to any given grant. The finding showed a positive relationship between the flow of total funds and output as well as the quality of output.

In the meantime, Grant and Buxton [21] investigates the economic returns of medical research funding. They found that private companies build on and interact with publicly funded research, conduct further research, and bring notable output to the market. In other words, public medical research spending can boost private-sector research spend (and vice versa). Similarly, the Association of Australian Medical Research Institutes [22] analyses medical research's existing and potential economic contribution to Australia. Through a systematic literature assessment, they reported Australia's medical research sector makes a significant and long-lasting contribution to the economy through job creation, downstream and upstream linkages with other sectors, and the creation of knowledge. In addition, medical research plays a significant and critical role in improving the health and well-being of the population. As a direct result of medical research, Australians remain healthier for longer due to improved treatments and improved healthcare that results from this research. They assert that with an increased focus on translation and commercialization through research funding, research works in the future is expected to continue to deliver excellent returns on investment. Subsequently, it will significantly increase funding for translational research that can directly improve health service delivery and clinical practice.

3. RESEARCH METHOD

This study employed a systematic literature review (SLR) to assess the ROI literature concerning research grant funding perspectives - the first attempt to incorporate the SLR of the ROI literature in the research grant funding realm. The SLR method allows the researcher to acquire a reliable knowledge base and accumulate content from past studies [14], [15]. The SLR was conducted in different stages based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) [23], namely: i) define the research question; ii) formulate the review protocol by identifying search terms, databases, and literature selection criteria; iii) search literature and screening search outcomes against the criteria before refining exclusion and inclusion criteria; iv) summarizing the literature and appraise literature quality; and v) synthesizing and reporting findings. The PRISMA methodology is preferable to other existing techniques due to its recognition of comprehensiveness and increased consistency across reviews [24], [25].

After determining the research aims, the researcher formulates a review protocol by identifying search terms, databases and literature selection criteria. The research data were screened through a literature review based on the inclusion criteria: i) study focusing on return on investment of research funding; ii) study published between 2001 until 2021 (as of December 2021). The keywords "ROI", including "research grant" and "grant funding", were utilized as the key search terms. To ensure the quality of the review, only research articles published in leading journals Scopus Sources Lists in 2021 are selected for the literature reviews. In addition, original research reports are also included in the search activities. This aligns with other researchers' justification that high-ranked published journals and original reports would be benchmarked and provide direction in the accuracy of research in any discipline [26], [27]. The PRISMA flowchart of the systematic literature review is presented in Figure 1.

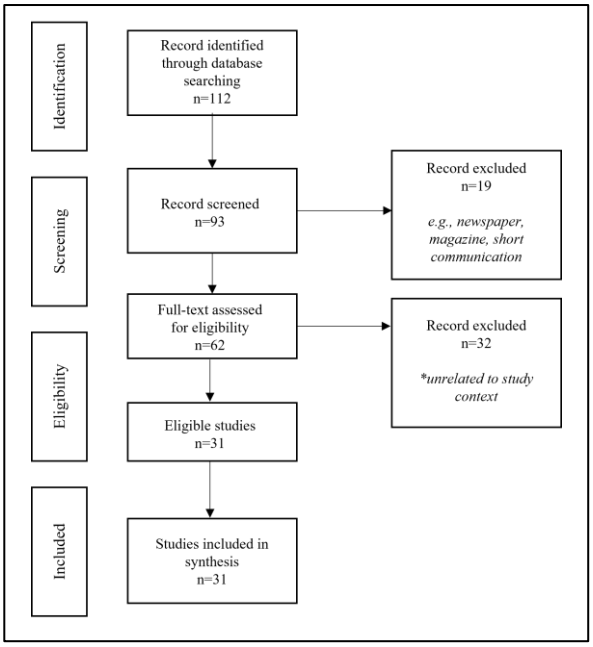

Figure 1. PRISMA flowchart

The searching process was carried out on selected leading and supporting databases based on the main and enriched keywords either by using advanced searching techniques such as Boolean operators, phrase searching, truncation, wild cards, and field code functions separately or by combining these searching techniques into the full searching string. Manual searching techniques were used, including handpicking or hand searching and snowballing (article inside the article). Only original research articles and original reports published in English are considered for this paper to ensure the quality and effectiveness of the literature review. Any conference papers, book series, commercial publications, and magazine articles were excluded from being reviewed in this paper. Specifically, out of 112 sources, 93 papers were identified during the first screen attempt based on the literature keywords search. In the screening process, 62 research papers were excluded, and only 31 articles were included in the final thematic analysis as shown in Figure 1. The emerging themes include research funding deliverables, outcomes, output, and ROI measurement.

4. RESULTS AND DISCUSSION

4.1. Deliverables of research grant funding

This study found that numerous researchers have proposed alternative research funding impact indicators over the past two decades [28]. They claim that research funding deliverables (outputs) are "any measurable, tangible or intangible, verifiable outcome, result or item that must be produced to complete a project or part of a project" [29]–[33]. Other researchers claimed that grant funding had individual effects, affecting overall organizational performance [34]–[36]. Besides the traditional tangible output assessments, intangibles and the social impact of the research funding have been utilized in recent ROI studies [37], [38]. However, these factors have been widely argued as insufficient for decision-makers to outline a straightforward, quantifiable economic "bottom line", usually provided by economic models [39].

The fundamentals of research assessment can be observed through the identified key performance indicators of research projects [39], such as: publications, graduate students (or talent), intellectual properties, knowledge translation, and additional grants secured. Notably, article publications have been deemed a vital research outcome, serving as testimony that the quality of research is on par with that of the global research community [38]. Similarly, scientific publications have been used to measure research productivity in European public and private universities [40]. Perhaps publications and talents are better indicators for measuring scientific value and yield. Measuring the number of publications is an acceptable key indicator to prove good results, promoting better research performance in ranking research universities [41]. However, several researchers [38], [39] claimed that publication counts do not reflect the quality of the knowledge contained therein.

Besides, talent generation is considered a product of research exercise, contributing to the vitality of the research enterprise [42]. Generating talent is essential for the growth and vitality of the research community. In this context, research exercises are crucial in identifying talented individuals and providing them with the necessary resources and opportunities to develop their skills. Through these exercises, individuals can develop the skills and knowledge necessary to contribute significantly to the research enterprise, ensuring its continued growth and vitality. However, there are limited ways to quantify their economic value, especially when compared to cross-disciplined, as different disciplines have different values [43]. Science indicators, which usually include statistics on graduate students, were found to unsuccessfully report the actual impact on economic value [44]. The question that arises is, what to report? What is the present cost of their studies or future value to the economy after a certain period? These values can be too arbitrary depending on how it is defined or assigned, potentially leading to matters that do not reflect the actual case.

4.2. Research output vs outcome

This paper collected and analyzed research-related performance attributes and measurements. We first compiled a list of research-related performance attributes from prior literature. The gathered data was critical in determining the standard research performance measures and the attributes to include in calculating the ROI. Based on the literature validation, there are three different deliverables of research funding: tangible output, intangible output, and outcome. Figure 2 reports the research-related performance attributes used for impact assessment.

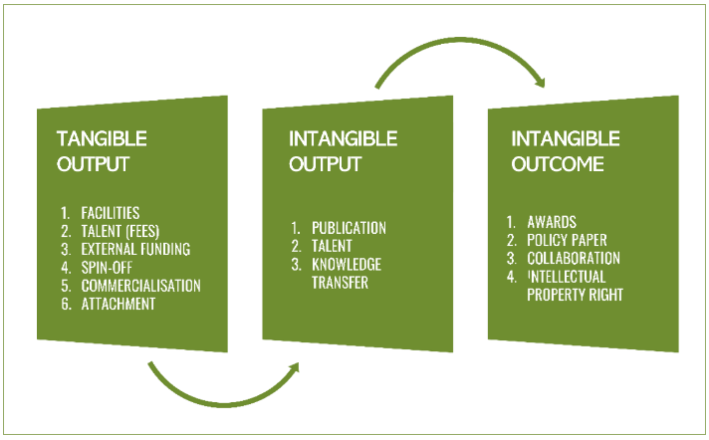

Figure 2. Deliverables of research funding

First, most study propose that the research-related performance measures can be divided into two different measures: output and outcome. Output measures quantify the number of deliverable units associated with a particular attribute; examples include the number of research projects that improve safety and the number of products produced due to projects that positively impact the environment. Meanwhile, outcome measures quantify the extent to which a research project achieves the desired result. The tangible outputs are treated as monetary value, including facilities obtained, talent fees (multiplier effect), external funding obtained, spin-off, commercialization, and job attachment. Meanwhile, the intangible outputs include publication metrics, talent salary (economic spillover effect and knowledge transfer program (to the community). Lastly, the intangible outcome includes awards and recognition, policy adoption, potential collaboration opportunities, and intellectual property rights.

Tangible outputs are generally easier to measure and convert into monetary value directly. On the other hand, intangible outputs are advantages that are difficult to calculate and allocate a financial value to. According to Remenyi, Bannister, and Money [45], a tangible benefit directly affects the organization's profitability, whereas an intangible benefit is anything challenging to quantify. Other researchers also acknowledged that tangible and intangible benefits have varying definitions and asserted that tangible benefits affect an organization's bottom line [46]. Specific intangible outputs are more easily quantifiable when compared to other measurable parameters, such as time or productivity. However, such a "proxy" is hard to classify [47]. In addition, most studies include tangible and intangible benefits for ROI calculation. They added that many research projects generate more value than can be quantified monetarily, and widespread agreement is that its value extends well beyond the tangible benefit [48].

It is well acknowledged that numerous researchers argue that intangible output should be defined as the benefits or detriments. However, they decided not to convert them into monetary value for various reasons, even in many cases where these programs can be converted [48]. Nonetheless, the intangible benefits are still significant in the evaluation process, although not converted to monetary values [49]. Also, they propose that intangible benefits could be more important than monetary or tangible measures. In most instances, the intangible outputs were complicated to convert to monetary values. However, the ROI calculation will potentially be less than the realized ROI, where intangible benefits are included [50]. Moreover, the ROI on tangible benefits alone cannot justify investment decisions. However, there was a lack of evaluation methodology for measuring the intangible benefits. Similarly, intangible costs such as researcher productivity are not easily measured and could complicate universities' ability to establish overall ROI accurately. Meanwhile, the intangible outcome must be analyzed in contexts specific to each case. Besides, it is essential to note few studies argued that what is intangible in one case may become tangible in another circumstance [47].

Identifying the correct intangible outcomes can be a powerful, persuasive, and valuable part of the ROI calculation [51]. The hidden values (such as skill, expertise and learning capabilities, network of relationships among individuals and organizations, and recognition) increasingly play an essential role in impact assessments [52]. Hence, taking the tangible output and the tangible and intangible outcomes into account when calculating the efficacy of research impact will provide a more transparent value of educational research grant performance. Consequently, this calls for formulating the ROI assessment together with the tangible and intangible deliverables in a unified measurement/framework.

4.3. Return of investment measurement

Academic or fundamental research, by definition, is experimental or theoretical work undertaken with the primary goal of acquiring new knowledge about the basic nature of phenomena and observable facts. Such output cannot be easily quantifiable into economic impact [53], [54]. Despite frequent criticisms of the appropriateness and effectiveness of measurement, there has been a marked absence of clear and specific arguments in scholarly literature over what academic research performance indicates. Notably, business organizations utilize ROI calculation to compare different investment scenarios to see which would produce the company's most significant profit and benefit. On the other hand, higher education institutions used ROI to assess the impact of research. However, because research funding outcomes are unique, there is scarce literature proposing a generic ROI calculation for research funding investments. As a result, conventional measures of research performance are limited based on publication output, citation counts, and impact factors.

Based on the literature review, there are four common ROI models utilized by various researchers to calculate the return from investment. First, the financial ROI is a performance metric used to evaluate an investment's efficiency or compare several different investments' efficiency. The financial-based ROI aims to quantify the rate of return on a particular investment concerning its cost by dividing an investment's benefit (or return on investment) by its cost and can be expressed as a percentage or ratio. Next, the cost-benefit analysis (CBA) is a systematic method for estimating the strengths and weaknesses of alternative solutions to identify the options that provide the best balance of benefits and cost savings (for example, in

spending, research activities, and functional business needs). Typically, a CBA is used to make comparisons, conclusions, or projections of a project value related to its cost [55]. It is frequently used in commercial transactions, business, policy rulings (particularly public policy), and investment in projects.

The Phillips ROI model is a credible step-by-step process that addresses the need for organizations worldwide to demonstrate value. The methodology is straightforward to implement and is a tried-and-true process for generating a balanced set of credible, realistic, and accurate data, particularly from sponsors and key stakeholders. Meanwhile, return on equity (ROE) measures how successfully a program meets its objectives, typically based on changes in performance after completing a project. More generally, ROE helps measure the effectiveness of a program on overall profitability. Lastly, the social return on investment (SROI) is a value-based approach to calculating the extra-financial value (such as social value or environmental values not yet considered in traditional financial accounts). Any entity can use it to analyze the effects on stakeholders, identify opportunities to improve performance and optimize investment performance. The SROI researchers use a method that does not involve assigning a financial value to all impacts [56]. Rather than that, the term "numerator" refers to information about the monetized value, quantifiable but not monetized, interpretive, and narrative in nature.

Notably, all these models carry significant limitations. First, it isn't easy to calculate ROI from research, mainly fundamental-based grants, as the main outputs are publications and talents (intangibles). Although these approaches would seem more acceptable indicators of scientific quality and productivity [57], they do not provide the decision-maker with the straightforward, quantitative economic "bottom line" that economic models do [56]. Numerous economists also argued that economic ROI calculations are insufficient for assessing government research spending [58]. Most ROI studies to date focus exclusively on the average return on past investment [59], [60]. Second, research expenditures are made on so-called "public goods," whose market value is difficult to quantify [61]–[63]. Third, despite the success of retrospective studies, there is no one-size-fits-all formula to follow [64]–[66].

Secondly, in terms of intrinsic research value, most of the research done worldwide focuses on the research impact rather than the research output economic value [17], [67], [68]. Notably, the calculation of ROI and predictions of future ROI cannot be made without prior identification of the research outcome and output [69], [70]. With abundant outcomes and output, limited literature appears to have proposed a generic ROI measurement and calculation from research grant investments. Lastly, most of the ROI measures for research grant expenditures focused on the economic value of quantifiable outputs of the research activities, such as patents, licenses, and others.

As research funding outputs include the tangibles and intangibles output, there is a need to propose a new value-based measure for the deliverable, gauging intangibles output's productivity and the monetary value of tangibles output. First, the Phillips ROI method is more applicable to the nature of the study despite not being developed for fundamental research. Meanwhile, although the SROI and ROI methods are established methods, SROI requires extensive impact study data. In addition, both methods were mainly utilized for translated research and required additional survey/data collection. Meanwhile, the original Phillips ROI includes impact data beyond the scope of ROI. Notably, the Phillips ROI model enables customization, adds value, and measures factors that matter and are specific. Formulating these heterogeneous elements in a unified framework will contribute to the scientometrics discipline. As the deliverables vary, they must be qualified, consolidated, and formulated toward a comprehensive model.

Nonetheless, this study is not without limitations. First, this study relied on self-reported data from past researchers, which may have introduced bias. The study also did not consider the long-term impact of research funding and other types of research funding and investments. Hence, future studies should investigate the spillover effects of research funding on the wider community, such as industry partners, government agencies, and society as a whole. Besides, they should explore the impact of research funding on individual researchers, including their career trajectories and the types of research projects they pursue. In addition, a comparative study across different disciplines will also allow future researchers to understand the unique ROI estimation from different fields of study.

Understanding the impact of research funding is essential for at least two reasons. First, granting research grants would influence a university's current and future performance. Secondly, for individual researchers, obtaining funding will affect their scientific production and career paths. Since limited research focuses on the spillover effects of research funding, future research should explore the critical secondary effects on research performance through its impact on the status and recognition of researchers. In addition, insights on research grant performance should be explored via qualitative and quantitative assessments from the perspectives of researchers and grant assessors. The quantitative and qualitative research results will provide university decision-makers with the necessary information to support future research funding activities.

This study suggests that the research grants output operational definitions should be communicated earlier. The funders must develop a specific policy at the beginning to ensure they can execute uniform research evaluations and measure the impact and ROI of research funding. Besides, engaging with stakeholders is essential in increasing the chances of research making an impact. Notably, a mindset transformation is crucial in creating a higher impact and reaping greater returns from research. It begins with awareness and understanding of what is meant by research impact. Clarifying the funding objectives and projecting the potential impact is the key to being mindful and ensuring that the goals, outcome, and impact will be achieved. Besides, it is highly recommended that policymakers include the role of stakeholders from the beginning of a research project and involve them as co-creators or co-developers in designing the research and ascertaining its direction and desired outcomes.

5. CONCLUSION

This study is among the early work related to the ROI assessment of the university's fundamental research funding. This study found that limited literature appears to have proposed a generic ROI measurement and calculation from research grant investments. In return, there are limited ways to quantify their economic value, especially when comparing cross-disciplinary as a different discipline. Henceforth, this paper is one of the earliest that consolidates three different deliverables of fundamental research funding by utilizing the tangible, intangible, and outcome. Besides, this paper found that it is not easy to calculate the return on investment from research grants – as they are evaluated based on tangible and intangible output and outcome. In addition, they do not provide the decision-maker with the simple, quantitative economic "bottom line" that basic economic models do. Second, most research conducted globally focuses on research impact rather than economic value when it comes to intrinsic research value.

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BIOGRAPHIES OF AUTHORS

Ahmad Taufek Abdul Rahman is a Physics Professor in the Faculty of Applied Science, Universiti Teknologi MARA (UiTM), Shah Alam, with several years since 1999 of teaching experience at the university level. Within the area of interest, he has written more than 30 articles and 3 books; and has also supervised and graduated several postgraduate students. His publication received 388 citations (H-index is 10). He has been invited to give a talk on his field of interest as well as on research management and monitoring. He can be contacted at email: ahmadtaufek@uitm.edu.my.

Mohd Hafiz Hanafiah is a Professor of Tourism Economics at the Faculty of Hotel & Tourism Management, Universiti Teknologi MARA, Malaysia. He completed his PhD in Hotel and Tourism Management from UiTM in 2016 and Master in Economics from Universiti Malaya in 2008. He is an active author within the tourism management, tourism economics and tourism destination competitiveness realm. He can be contacted at email: hafizhanafiah@uitm.edu.my.

Umi Marshida Abd Hamid is a Senior Lecturer at the Faculty of Applied Science, Universiti Teknologi MARA, Shah Alam, Malaysia. She obtained her DPhil (Glycobiology) from University of Oxford, United Kingdom. She is an active researcher in the molecular biology cell, biology and cancer research area. She can be contacted at email: marshida@uitm.edu.my.

Nor Azura Md Ghani is a Professor at the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam Malaysia. She obtained her Ph.D. in Statistics from Universiti Kebangsaan Malaysia. She is an active researcher in the forensic statistics, image processing and pattern recognition research area. She can be contacted at email: azura@uitm.edu.my.

Nur Adilah Md Zain is a Senior Lecturer at the Faculty of Hotel & Tourism Management, Universiti Teknologi MARA, Malaysia. She completed her Ph.D. in the University of Sydney, Australia in 2020 and Master in Tourism Management from Universiti Teknologi MARA, Malaysia in 2014. She is an active author within the area of tourism destination, medical tourism and tourism management. She can be contacted at email: nuradilahzain@uitm.edu.my.